Seminar SAW: History of Mathematics, History of Economical and Financial Practices
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Grains and granaries

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Grain and time calculations in the 4th millennium BC Mesopotamia

Slide 1: silos and baskets
Seminar SAW: History of Mathematics, History of Economical and Financial Practices

March 9, 2012: "Grain and Time Calculations in 4th Millennium BC Mesopotamia"

Slide 2: Libyan granary
Libyan village Qasr al-Haj with Berber granary from the 2nd half of the 12th century. Here you can see the winch used to haul baskets of grain to the 2nd story.

Slide 3: baskets
Luhya baskets for carrying grain on sale at Kakamega market in Kenya; if used for flour, their inside surfaces are smeared with cow dung to close the gaps.

Slide 4: grain scoop
Simple grain measuring and transportation devices included silos at the larger-scale, bags, baskets and pots at the middle, and smaller baskets, boxes and ceramic containers at the smaller scale
Even in the Ozarks of Missouri and Arkansas, the traditional grain scoop is nowadays reduced to decoration

Slide 5: grain doubling exercise
P390441 = Denis Soubeyran, *RA* 78, 30-35 6
1 barley-corn: by a single barley-corn I increased,
= approximately 0.05g
2 barley-corns in the 1st day;
4 barley-corns in the 2nd day;
8 barley-corns in the 3rd day;
...
2 'thousand' 7 'hundred' 37 talents 1/2 mina 2 1/3 shekels 4 barley-corns in the 30th day.
= approximately 49,710kg
('lim' used as sexagesimal 600, not decimal 1000;
'me' used as sexagesimal 60, not decimal 100)

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Slide 6: Benoit Mandelbrot, 1985
Bottomless wonders spring from simple rules … repeated without end

Slide 7: Uruk chronology

Slide 8: Bullae 1
The large majority of clay balls from excavations of 4th millennium sites are, like the examples to the left from the antiquities market (top) and from Susa (bottom), unopened.
Pierre Amiet, Louvre, Susa
Schmandt-Besserat, Austin, everything
Helen Kantor, Chicago , Choga Mish

Slide 9: Schøyen bullae 2
Recent acquisitions of the Schøyen collection were cut open to reveal their contents, including one (MS 4631 below) with so-called "silver tokens"

Slide 10: Bullae 3a
A recent acquisition of Cornell University

Slide 11: Bullae 3b (with contents)

Slide 12: Numerical tablet 2 (Susa)
This numerical tablet from Susa, Late Uruk, ca. 3400 BC, contains impressions of an apparent ovoid token (the notation represents ca. 16,000 liters of grain).

Slide 13: Mark Wilson texts

Slide 14: Jebel Aruda, Syria: numerical texts

Slide 15: Attested proto-numerical systems in bullae and on numerical tablets

Slide 16: Butter oil, sexagesimal
Small account of dairy fat delivered in vessels, tallied in the sexagesimal system

Slide 17: Grain: capacity system

Slide 18: The early work
Picture from Berlin Babylonian mathematics group (some papers published in Høyrup/Damerow, Changing Views on Ancient Near Eastern Mathematics (=BBVO 19; Berlin, 2001)

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Slide 19: Determining systems
The best method is of course to discover notations that were combined in totals, as in the two previous texts on butter oil and grain; failing such records, Damerow led in the statistical determination based on counts of iterating signs and the sign sequences, looking particularly for strings of at least three signs; this example takes a qualified version of basic signs suspected of qualifying grain

Slide 20: Numerical systems

Slide 21: MSVO 1, 10
represents a potential implicit calculation of seed grain and field measures based on a relationship of 15N1 grain per 1N14 GAN2 and thus if the surface measures system remained constant an absolute measure of N1 grain of ca. 25 liters

Slide 22: MSVO 4, 66a
This is the key text employed by Friberg to decipher the grain system; purchased in Baghdad in 1933 by the then Iraq Museum director Julius Jordan, it was published by Adam Falkenstein (Falkenstein-Jordan) in 1937 in OLZ 40 with correct hand copy but fallacious interpretation (6N1 = 1N14 because of calculated 40% loss of grain in milling, thus still N14 = 10). With this text, the relative size of the units below N1 is evident

Slide 23: MSVO 4, 66b
including down to the level of the sign GAR/NINDA+ strokes that corresponded to N30 or 6 ovoid impressiions in a circle

Slide 24: MSVO 4, 66c
totals

Slide 25: MSVO 3, 11
Erlenmeyer 28 was auctioned at Christie's London on 13 December 1988 to Martin Stansfeld, Monaco, for £40,000; on 18 October 2005 to Bolaffi/Rome for £160,000 (with pre-mium: £187,200, ca. €225,000)
grain expended
for ŠEN$_b$ GAL: $21N_1 \div 63N_{24} = 3N_{24}$ per N_1
for ŠEN$_b$ TUR: $160N_1 \div 192N_{24} = 1.2N_{24}$ per N_1
for ŠEN$_c$: $378N_1 \div 194N_{24} \approx .5N_{24}$ per N_1
for DUG$_a$: $10N_1 \div 24N_{24} \approx .4N_{24}$ per N_1

Slide 26: MSVO 1, 27

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Now to the question of time calculations in the archaic texts. This decipherment actually ran first through a simply achieved interpretation of grain notations represting 1/10—again, dependent on the correct interpretation of the grain system; in the text here,

1N45 · a = 1N14
∴ a = 1/10
5N14 · a = 3N1
∴ a = 1/10

Slide 27: MSVO 1, 121

The second text introduces the ideogram U4 representing, presumably, a rising sun, found often in close association with numerical notations; if we take this example, reading the first line from right to left:

(3N1 2N39 1N24) = 35N24 · a = (1N42 1N24 1N30a) = 3 1/3 N24
∴ a = 1/10

this discrepancy might have resulted from the difficult calculation of 1/10 of 2N39 1N24: round off to 2N39, 2N39 x 1/10= 1/5 N39 = N29. N29, unattested in JN, had finally to be expressed as either N28 or N30

U4xN1 + 5N8 = 3N1 2N42 1N24 = 35N24
? U4xN1 = 1 month of 30 days
? N8 = 1 day

Slide 28: MSVO 1, 122

Now there are also several account that appear to contain year notations; here we first calculate at a rate of N24 per day and assuming a 360-day year:

3N57+U4 x 1N24 = 1080N24 (1N57+U4 = 360)
then implicitly adding 1/10 = 1188N24
= 1N45 9N14 4N1 4N39
(600 + 540 + 40 + 8N24)

I might note that Friberg has plauysibly interpreted the meaning of these long-term grain calculations to lie in the cultic rations offered to deities, or perhaps more likely to statues representing these same donors placed before statues of deities—of course in the end landing on the table of the priests

Slide 29: MSVO 4, 27

Finally, this interesting text with 24 written inside the U4 sign,
P005429 = MSVO 4, 27
obv. i
1.a. 4(N14)# , |U4x(2(N14).4(N01))| GAR SZE~a
4N14 grain in 24 months: GAR(-rations),
4N14 = 720N30
24 x 30 = 720 days, 1N30 each day
1.b. 2(N01)# 2(N39~a) , TAR~a

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2N1 2N39 are “the cut”;
2N1 2N39 = 72 N30
calculation: 720 ÷ 10 = 72

Slide 30: calendrical 1
Vicenzio Formaleoni, Sources of Errors in the Cosmography and Geography of the Ancients [Dei fonti degli errori nella cosmografia e geographia degli Antichi] (Venice 1789): “The length of the year was therefore indisputably 360 days at the time of the first observers (of the deluge)” [La lunghezza dell’anno era dunque incontrastabilmente de 360 giorni al tempo dei primi contemplatori]=

Slide 32: calendrical 2
Looking at both grain and calendrical systems, we may speculate about further connections: first, that the grain basic unit N1 corresponds to one month, which in 3rd millennium rationing systems was always the basis of household administrations, and of course the clear relationship between NINDA/N30 and one rationing day; but second we may wonder whether the grain division into presumably basket metrologies also represented an ancient week of 6 days and a month of 5 weeks; finally, the matter of bisexagesimal strictly for rationed items, specifically NINDA; and finally, the possibility that the sexagesimal system is itself intimately related the the ideal month of 30 days, at 2 rationed NINDA per day.

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